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THE TRANSMISSION OF NEUTRONS AND GAMMA-RAYS THROUGH AIR SLOTS. PART VI. THE EFFECT OF MULTIPLE OFFSETS ON THE NEUTRON TRANSMISSION OF AN AIR SLOT

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September 1, 1954

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THE TRANSMISSION OF NEUTRONS AND GAMMA-RAYS THROUGH AIR SLOTS

Part VI

The Effect of Multiple Offsets on the Neutron Transmission of an Air Slot

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1 September 1954

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REACTOR DEPARTMENT

BROOKHAVEN NATIONAL LABORATORY
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Part VI

The Effect of Multiple Offsets on the Neutron Transmission of an Air Slot

This investigation has considered two types of slots containing more than one offset. In the first type, all of the offsets are smaller than the slot thickness and they are arranged so that a straight-through slot still exists. The other case involves slots for which the offsets are large compared with the slot thickness. The situation in which one or more of the offsets is only slightly larger than the slot thickness has not been studied because of the difficulty in fabricating such slots reproducibly.

When a straight-through slot exists, as in the first type mentioned aboyc, we might expect that the offset slot would behave as a straight slot whose thickness was determined by the effective defining edges of the offsets. Runs 1915 and 1916, see Figs. 2 to 4, consist of traverses above a 0.5 inch slot containing two 0.25 inch offsets. The traverses are very similar to those which have been obtained with a 0.25 inch straight slot in qualitative agreement with our expection.

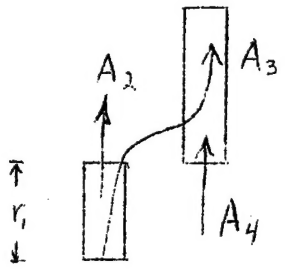
With offsets which are large compared with the slot thickness, the reproducibility of the measurements is good. Data which have been obtained with large offsets may be used to test the simple assumption that one may estimate the transmission of a slot with multiple offsets in a straightforward manner on the basis of the transmission of similar slots with only one offset. The following paragraph is an attempt to estimate, on such a basis, the peak transmittal flux of a slot containing two offsets.

Consider the case, illustrated in Fig. 1 opposite, of a slot of overall length, L, containing two offsets with the first offset a distance r_1 from the bottom of the slot and the second offset at r_2. The thickness of all the sections is the same and r_1 is less than r_2. The flux observed at the exit of the slot may be divided, somewhat arbitrarily, into seven components. Component 1 represents the transmission of the medium and will be subtracted from all measurements to yield the transmission of the slot. Components 2, 5, and 7 are each aware of the existence of only one section of the slot. Components 3, 4, and 6, however, negotiate at least one of the offsets. The transmission of the slot, $T_{r_1 r_2}$, is then:

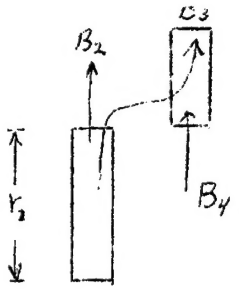
$$T_{r_1 r_2} = \text{Components } (4+6) + \text{components } (3+5) + \text{component 2} + \text{component 7}$$

Consider now the two situations A and B, illustrated below, for which the overall length of the slots is also L. The three components of the transmitted flux, in addition to the background, are indicated.

A



B



The transmission of the slot with a single offset of r_1 is:

$$T_{r_1} = \text{Component } A_2 + \text{component } A_3 + \text{component } A_4$$

Similarly when the offset is at r_2:

$$T_{r_2} = \text{Component } B_2 + \text{component } B_3 + \text{component } B_4$$

The assumption, mentioned above, which we wish to make is that the effect of the offset is independent of the changes in spectrum or angular distribution which the presence of another offset introduces so that the following equation is valid.

$$\text{Components } (A_3 + A_4) \cdot \frac{\text{components } (B_2 + B_3)}{T}$$

$$= \text{components } (4 + 6) + \text{components } (3 + 5) \qquad (1)$$

where T is the transmission of a straight slot of length L. If we denote the ratio $B_2 + B_3/T$ by the symbol a_2, and the ratio $A_3 + A_4/T$ by a_1 equ. 1 may be rewritten as:

$$Ta_1a_2 = \text{components } (4 + 6) + \text{components } (3 + 5) \qquad (2)$$

Since components A_2 and B_4 are usually small, a_1 and a_2 may be approximated as follows:

$$a_1 = \frac{T_{r_1} - \text{comp } A_2}{T} \approx \frac{T_{r_1}}{T}\ ; \quad a_2 = \frac{T_{r_2} - \text{comp } B_4}{T} \approx \frac{T_{r_2}}{T}$$

The transmission of the slot with two offsets may then be expressed in terms of experimental (or analytical) transmissions of the single offset and straight slots plus the small components 2 and 7.

$$T_{r_1r_2} = T \cdot \left(\frac{T_{r2}}{T}\right)\left(\frac{T_{r_1}}{T}\right) + \text{component 2} + \text{component 7} \qquad (3)$$

Runs 1869 and 1870, shown in Figs. 2 to 4, indicate the transmission of a 0.5 inch thick slot with two 1.8 inch offsets for which L = 48 inches, r_1 = 12 inches, and r_2 = 36 inches. From the information presented in Part V of this series of reports[1], a_1 = .0172 and a_2 = .0083 for measurements close to the end of the slot. Component 7 is small, about 1 nv/Mw, immediately above the slot and is everywhere smaller than the background resulting from the transmission through the water medium. In this example, component 2 may be neglected.

For a point close to the top of the slot:

$$T \cdot a_1 \cdot a_2 + \text{component } 7 \simeq 6 \text{ nv/Mw}$$

The experimental determination of the transmission was

$$12.5 - 2.4 = 1.01 \cdot 10^{1} \text{ nv/Mw.}$$

The measurements 7.5 inches beyond the end of the duct indicated a total flux about twice the background. The product Ta_1a_2 is, however, appreciably less than the background. For the slot discussed above the simple assumption which was made leads to an estimate for the transmission which is of the right order, but which cannot be said to be in good agreement with the observed transmission.

From runs 1898 and 1897, Figs. 5 to 7, it may be seen that the introduction of a third offset is not very effective. There is an indication that even if the background (component 1) were much less, the effectiveness of the third offset would be significantly less than the first or second. From the practical standpoint, more than two offsets would appear to be unnecessary.

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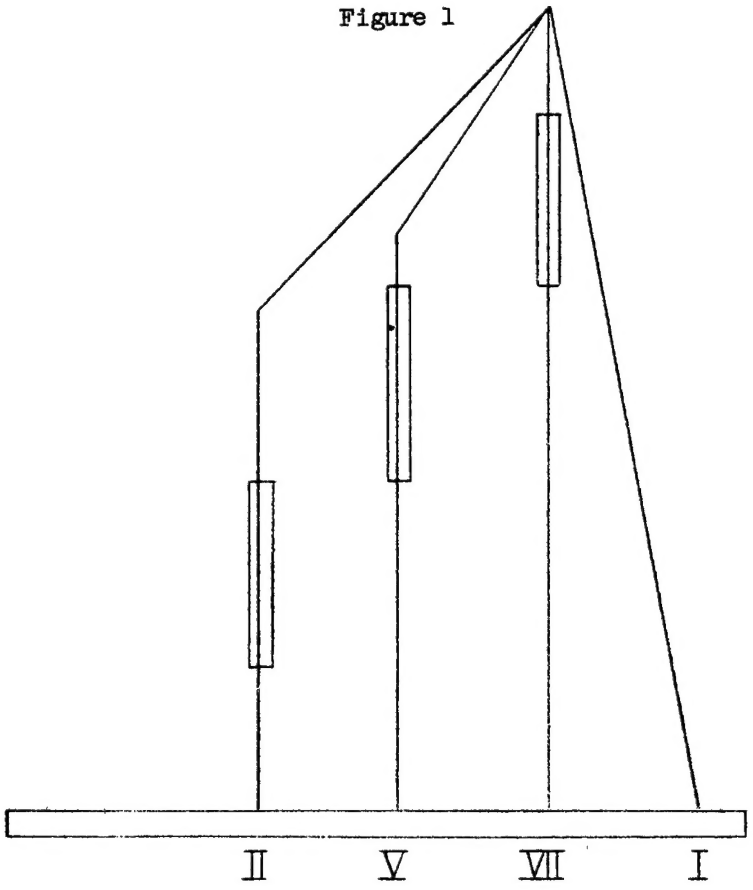
Figure 1



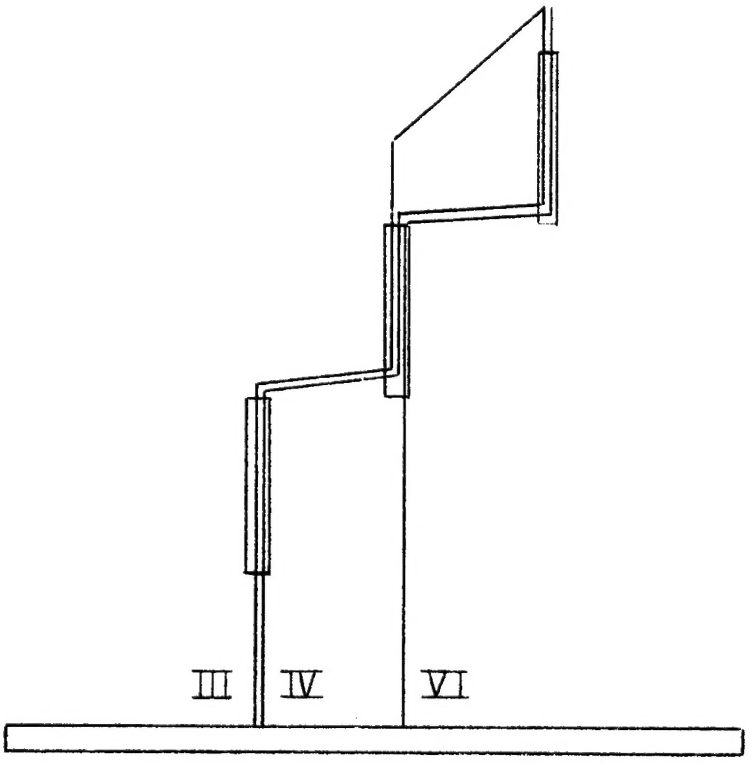
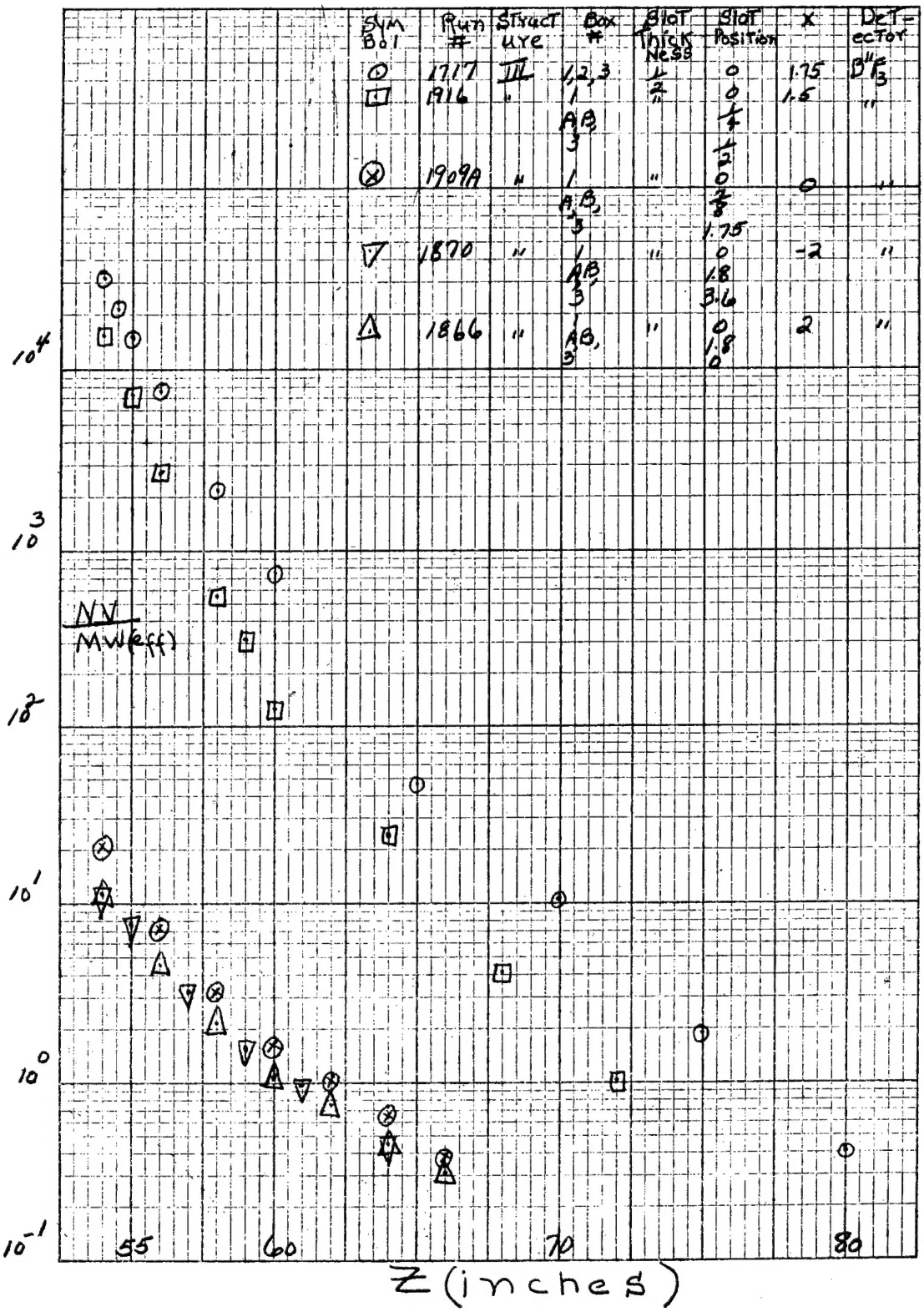
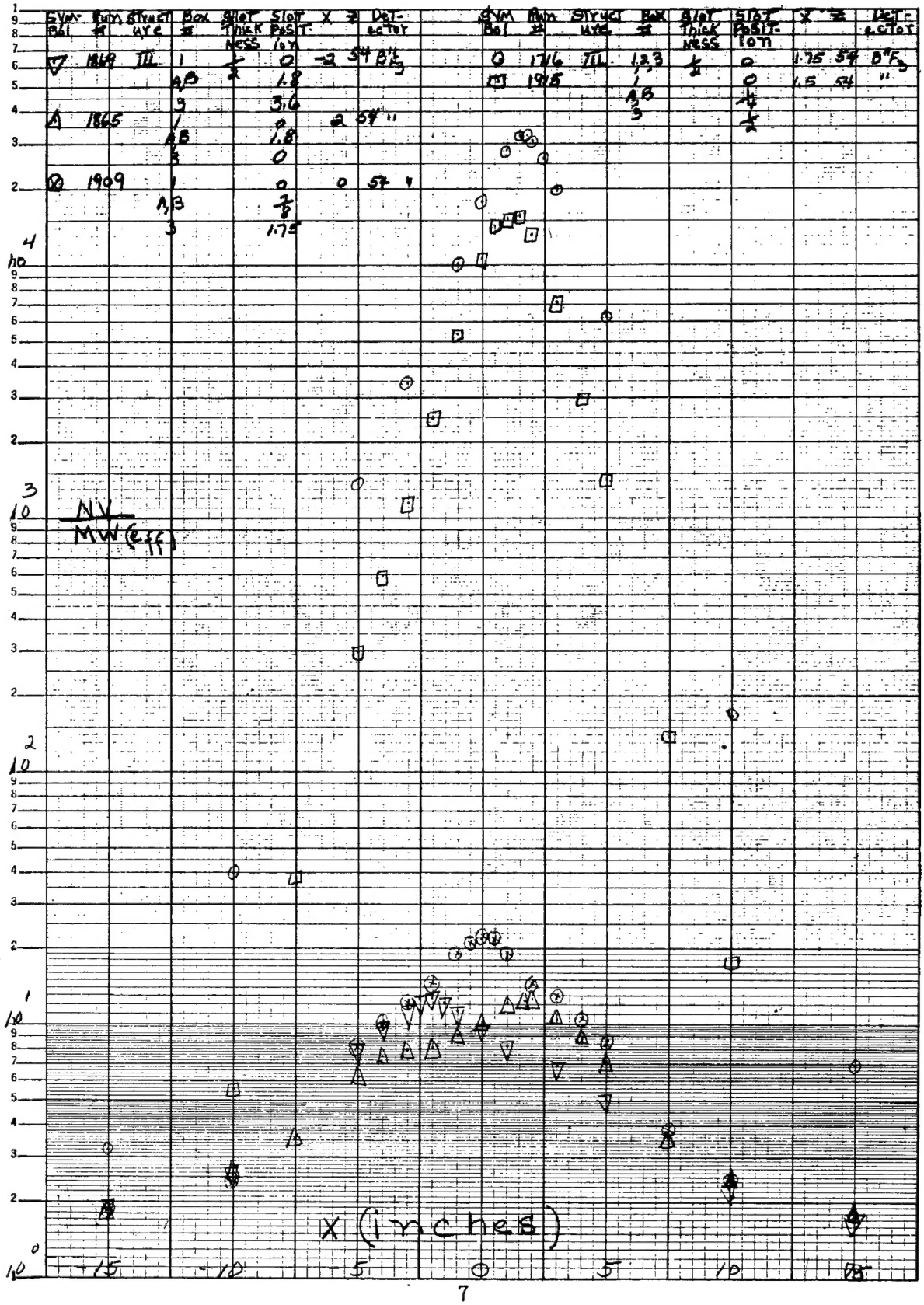


Figure 2



SYM BOL
Run #
STRUCT URE
Box #
SLOT THICK NESS
SLOT POSITION
X
DET-ECTOR
1717 III 1,2,3 1/2 0 1.75 B''F3
1916 " 1 A,B, 3 " 0 1/4 1/2 1.5 "
1909A " 1 A,B, 3 " 0 7/8 1.75 0 "
1870 " 1 A,B, 3 " 0 1.8 3.6 -2 "
1866 " 1 A,B, 3 " 0 1.8 0 2 "
NV / MW(eff)
10^4
10^3
10^2
10^1
10^0
10^-1
55
60
70
80
Z (inches)

Figure 3



SYM-BOL
RUN #
STRUCT-URE
BOX #
SLOT THICK-NESS
SLOT POSIT-ION
X
Z
DET-ECTOR
1869 III 1 1/2 0 -2 54 B"F3
A,B 1.8
3 3.6
1865 1 0 2 54 "
A,B 1.8
3 0
1909 1 0 0 54 "
A,B 7/8
3 1.75
1716 III 1,2,3 1/2 0 1.75 54 B"F3
1915 1 0 1.5 54 "
A,B 1/4
3 1/2
NV / MW(eff)
X (inches)
-15
-10
-5
0
5
10
15

Figure 4

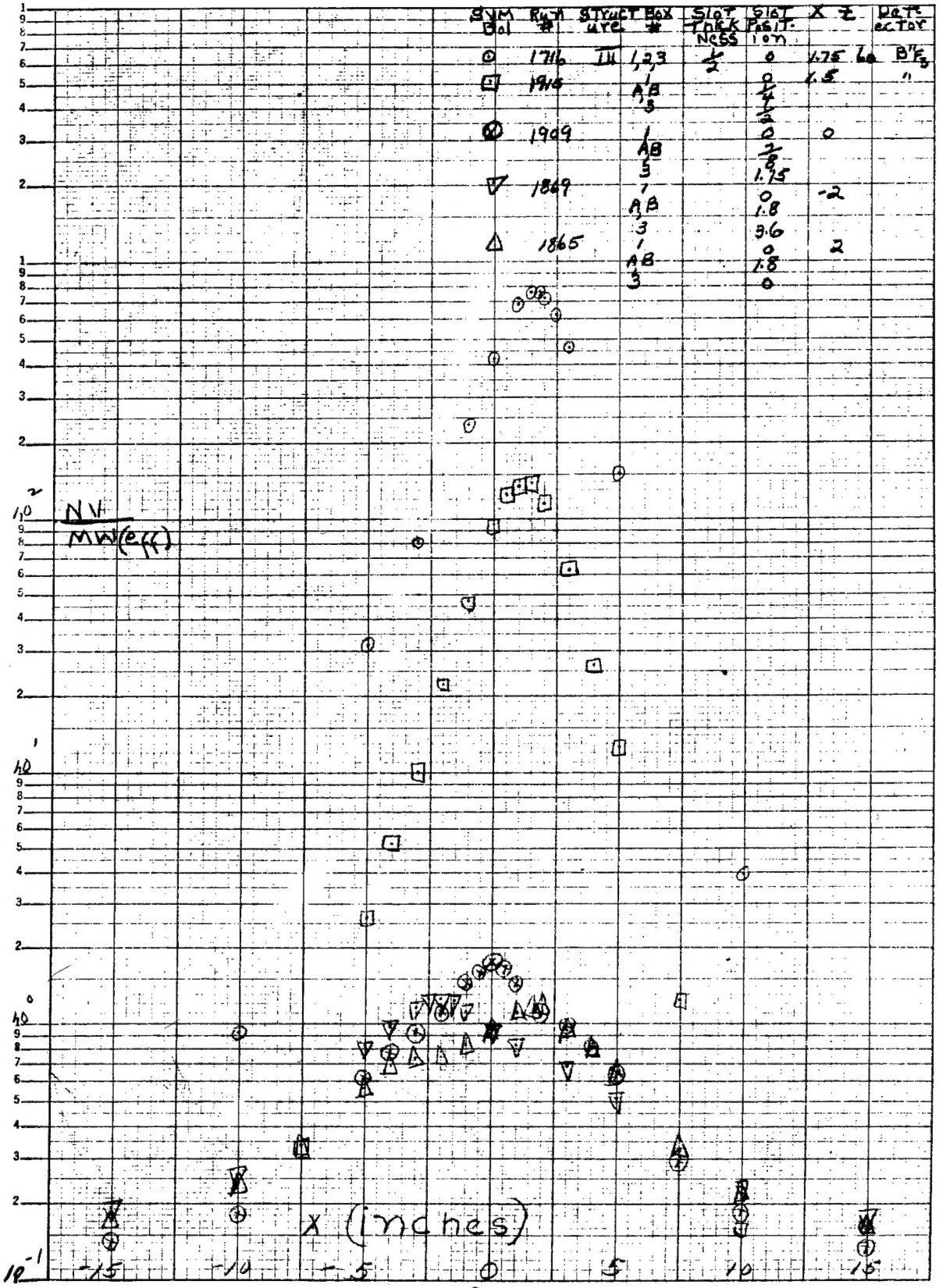

SYM Bol
Run #
Structure
Box #
Slot Thickness
Slot Position
X
Z
Detector
1716
1916
1909
1869
1865
NV / MW(eff)
X (inches)
-15
-10
-5
0
5
10
15

Figure 5

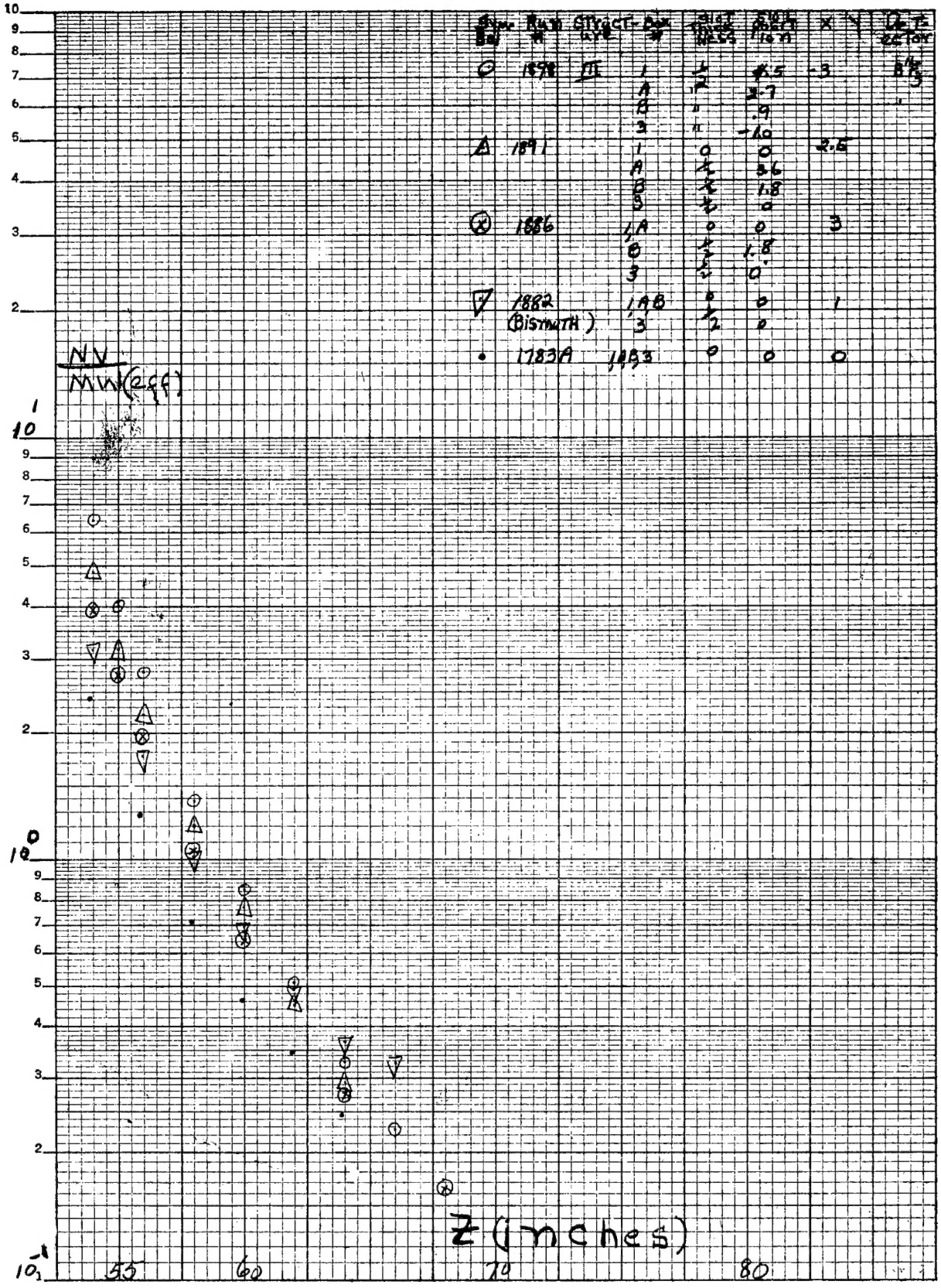


Figure 6

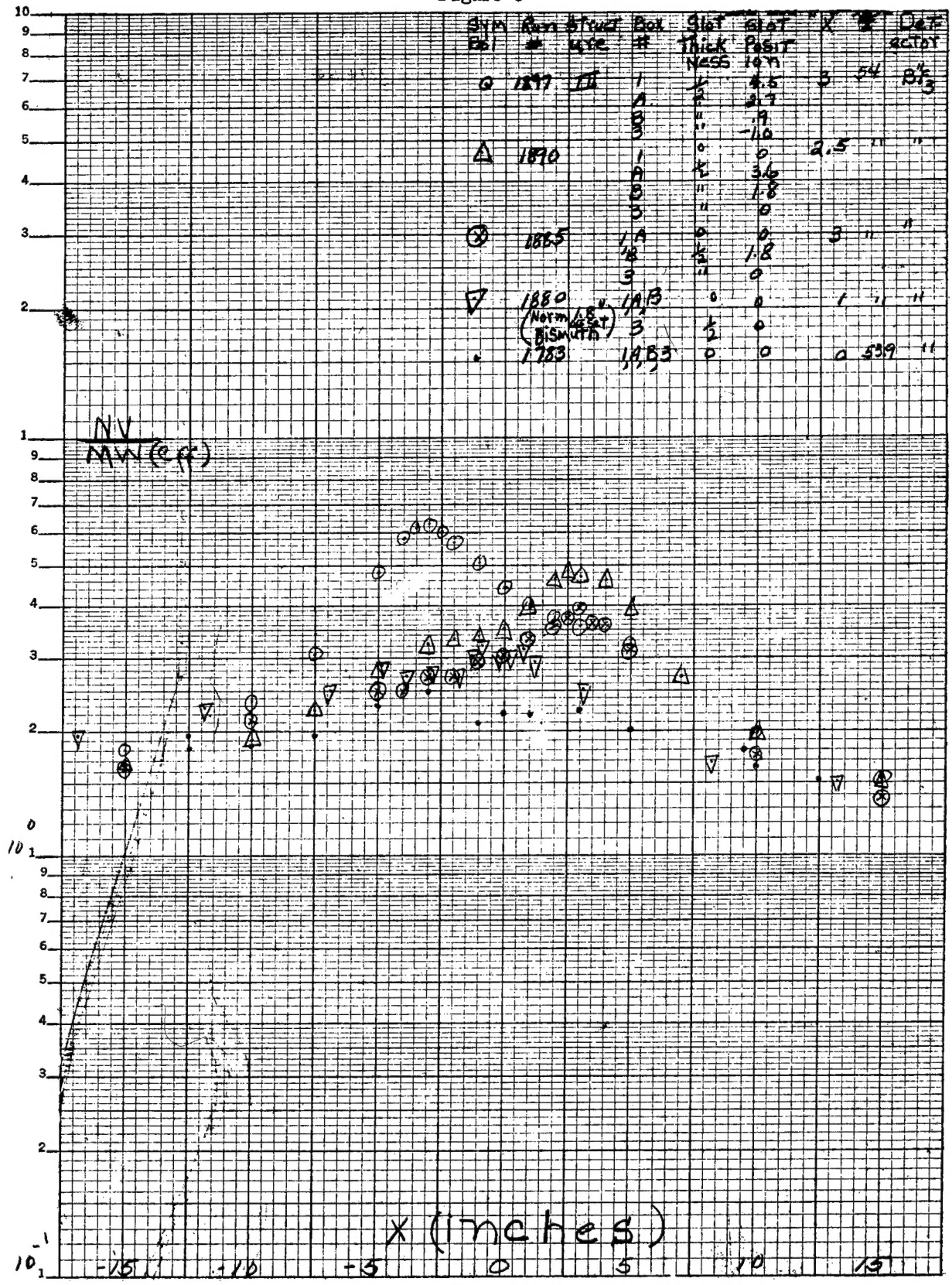


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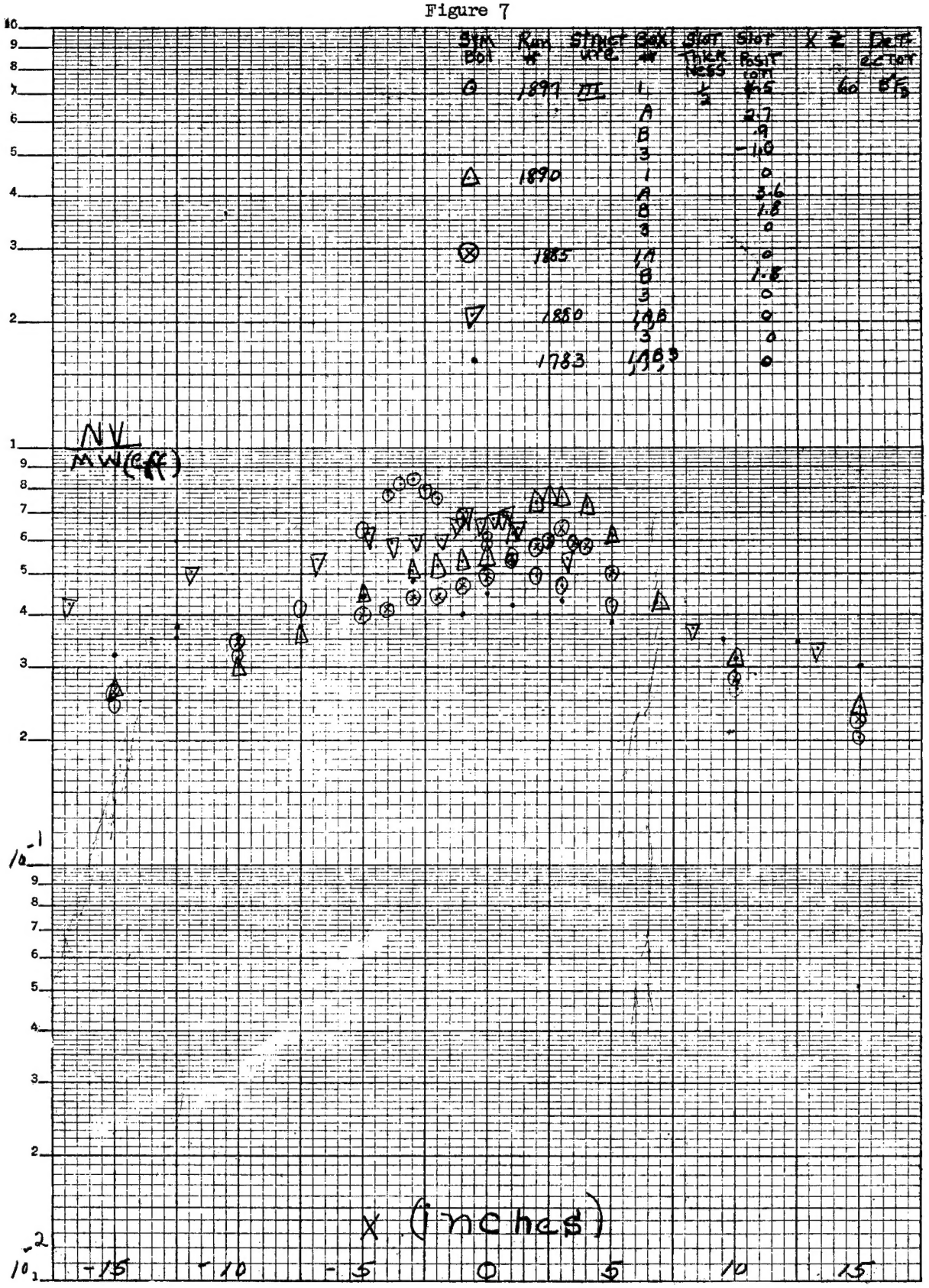
Figure 7



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